US009201414B2

(12) **United States Patent**
Kantzes et al.

(10) **Patent No.: US 9,201,414 B2**
(45) **Date of Patent: Dec. 1, 2015**

(54) **INTRINSICALLY-SAFE HANDHELD FIELD MAINTENANCE TOOL WITH IMAGE AND/OR SOUND CAPTURE**

(75) Inventors: **Christopher P. Kantzes**, Minneapolis, MN (US); **Brad N. Mathiowetz**, Lakeville, MN (US); **Todd M. Toepke**, Eden Prairie, MN (US); **Kun Yang**, Eden Prairie, MN (US); **Adam E. Lund**, St. Louis Park, MN (US); **Donald R. Lattimer**, Chaska, MN (US); **Brian A. Franchuk**, Richfield, MN (US)

(73) Assignee: **Fisher-Rosemount Systems, Inc.**, Austin, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 533 days.

(21) Appl. No.: **13/191,604**

(22) Filed: **Jul. 27, 2011**

(65) **Prior Publication Data**

US 2012/0038760 A1 Feb. 16, 2012

Related U.S. Application Data

(60) Provisional application No. 61/368,477, filed on Jul. 28, 2010.

(51) **Int. Cl.**
H04N 7/18 (2006.01)
G05B 19/042 (2006.01)

(52) **U.S. Cl.**
CPC ***G05B 19/042*** (2013.01); ***G05B 19/0426*** (2013.01); *G05B 2219/23018* (2013.01); *G05B 2219/23054* (2013.01); *G05B 2219/23126* (2013.01); *G05B 2219/23163* (2013.01); *G05B 2219/23406* (2013.01); *G05B 2219/23445* (2013.01); *G05B 2219/23446* (2013.01); *G05B 2219/24001* (2013.01);

(Continued)

(58) **Field of Classification Search**
USPC 348/61; 455/41
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,195,392 A 3/1993 Moore et al. 73/866.5
5,309,351 A 5/1994 McCain et al. 364/132

(Continued)

FOREIGN PATENT DOCUMENTS

CN 101763576 6/2010
CN 201518523 U 6/2010

(Continued)

OTHER PUBLICATIONS

Invitation to Pay Additional Fees for international patent application No. PCT/US2010/034889 dated Sep. 15, 2010.

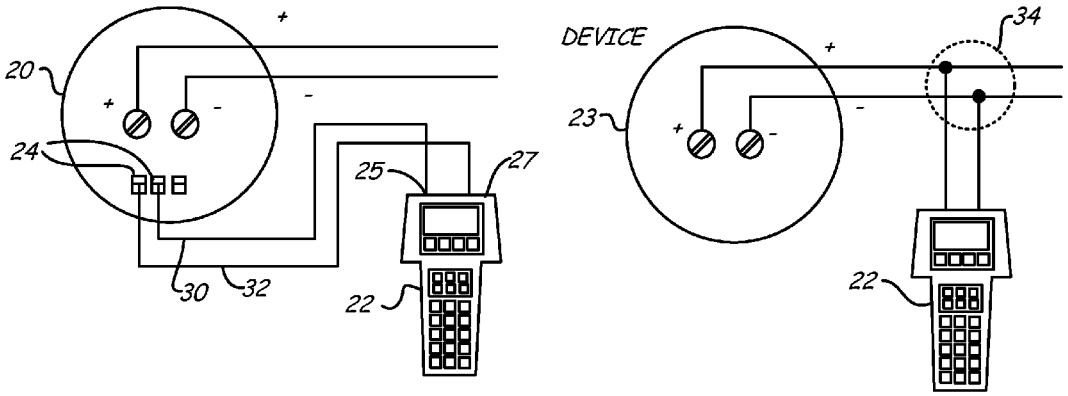
(Continued)

Primary Examiner — Dave Czekaj
Assistant Examiner — Leron Beck
(74) *Attorney, Agent, or Firm* — Christopher R. Christenson; Kelly, Holt & Christenson, PLLC

(57) **ABSTRACT**

An intrinsically-safe handheld field maintenance tool includes a process communication module configured communicatively couple to a field device. A camera is configured to obtain at least one image relative to the field device. A controller is coupled to the process communication module and operably coupled to the camera. The controller is configured to store the at least one image relative to the field device. The handheld field maintenance tool may also include or employ an audio input device to capture audio files.

7 Claims, 7 Drawing Sheets



(52) **U.S. Cl.**

CPC *G05B 2219/24056* (2013.01); *G05B 2219/25062* (2013.01); *G05B 2219/25428* (2013.01); *G05B 2219/31121* (2013.01); *G05B 2219/31197* (2013.01); *G05B 2219/31475* (2013.01); *G05B 2219/32007* (2013.01); *G05B 2219/32144* (2013.01); *G05B 2219/32226* (2013.01); *G05B 2219/33331* (2013.01); *G05B 2219/35422* (2013.01); *G05B 2219/35429* (2013.01); *G05B 2219/36122* (2013.01); *G05B 2219/36128* (2013.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,442,632	A	8/1995	Burton et al.	371/20.1
5,903,455	A	5/1999	Sharpe, Jr. et al.	364/188
6,033,226	A	3/2000	Bullen	434/219
6,205,239	B1 *	3/2001	Lin et al.	382/149
6,211,649	B1	4/2001	Matsuda	320/115
6,236,223	B1	5/2001	Brady et al.	324/750.3
6,377,859	B1	4/2002	Brown et al.	700/79
6,629,059	B2	9/2003	Borgeson et al.	702/183
6,633,782	B1	10/2003	Schleiss et al.	700/26
6,725,182	B2	4/2004	Pagnano et al.	702/188
6,971,063	B1	11/2005	Rappaport et al.	715/733
7,013,184	B2	3/2006	Romagnoli et al.	700/17
7,117,122	B2	10/2006	Zielinski et al.	702/183
7,120,391	B2	10/2006	Stengele et al.	455/41.3
7,188,200	B2	3/2007	Griech	710/100
7,233,745	B2 *	6/2007	Loechner	398/128
7,337,369	B2	2/2008	Barthel et al.	714/43
7,400,255	B2	7/2008	Horch	340/572.7
7,421,531	B2	9/2008	Rotvold et al.	710/315
7,454,252	B2	11/2008	El-Sayed	700/21
7,505,819	B2	3/2009	El-Sayed	700/21
7,506,812	B2	3/2009	von Mueller et al.	235/449
7,675,406	B2	3/2010	Baier et al.	340/506
7,733,833	B2	6/2010	Kalika et al.	370/338
7,797,061	B2	9/2010	El-Sayed	700/21
8,000,815	B2	8/2011	John et al.	700/18
8,036,007	B2	10/2011	Woehrle	363/65
8,059,101	B2	11/2011	Westerman et al.	345/173
8,060,862	B2	11/2011	Eldridge et al.	717/121
8,060,872	B2	11/2011	Da Silva Neto	717/177
8,074,172	B2	12/2011	Kocienda et al.	715/263
8,126,145	B1	2/2012	Tewari et al.	380/255
8,150,462	B2	4/2012	Guenter et al.	455/557
8,180,948	B2	5/2012	Kreider et al.	710/313
8,224,256	B2	7/2012	Citrano, III et al.	455/67.11
2001/0047504	A1	11/2001	Aoyama	714/799
2002/0004370	A1	1/2002	Stengele et al.	455/39
2002/0007237	A1	1/2002	Phung et al.	701/33
2002/0027504	A1	3/2002	Davis et al.	340/540
2002/0086642	A1	7/2002	Ou et al.	455/69
2002/0171558	A1	11/2002	Bartelheim et al.	340/825.49
2003/0050737	A1	3/2003	Osann, Jr.	700/276
2003/0109937	A1	6/2003	Zielinski et al.	700/1
2003/0204373	A1	10/2003	Zielinski et al.	702/184
2003/0229472	A1	12/2003	Kantzes et al.	702/183
2004/0039458	A1	2/2004	Mathiowetz et al.	700/17
2004/0093100	A1	5/2004	Gleis	
2004/0111238	A1	6/2004	Kantzes et al.	702/183
2004/0193287	A1	9/2004	Lefebvre et al.	700/1
2004/0204193	A1	10/2004	Li et al.	455/575.1
2004/0228184	A1	11/2004	Mathiowetz	365/202
2004/0230327	A1	11/2004	Opheim et al.	700/83
2005/0164684	A1	7/2005	Chen et al.	455/414.1
2005/0222698	A1	10/2005	Eryurek et al.	700/90
2005/0223120	A1	10/2005	Scharold et al.	710/1
2006/0014533	A1	1/2006	Warren	455/423
2006/0087402	A1	4/2006	Manning et al.	340/3.1
2006/0206277	A1	9/2006	Horch	702/82
2006/0290496	A1	12/2006	Peeters	340/572.1
2006/0291438	A1	12/2006	Karschnia et al.	370/338
2007/0161352	A1	7/2007	Dobrowski et al.	455/69
2007/0161371	A1	7/2007	Dobrowski et al.	455/423
2007/0179645	A1	8/2007	Nixon et al.	700/83
2007/0208279	A1	9/2007	Panella et al.	600/595
2007/0280507	A1 *	12/2007	Murali	382/107
2008/0114911	A1	5/2008	Schumacher	710/72
2008/0234837	A1	9/2008	Samudrala et al.	700/19
2008/0268784	A1	10/2008	Kantzes et al.	455/66.1
2009/0065578	A1	3/2009	Peterson et al.	235/382
2009/0094466	A1	4/2009	Matthew et al.	713/300
2009/0111378	A1 *	4/2009	Sheynman et al.	455/41.1
2009/0125713	A1	5/2009	Karschnia et al.	713/153
2009/0171483	A1	7/2009	Scheuermann	700/83
2009/0177970	A1	7/2009	Jahl et al.	715/735
2009/0228121	A1	9/2009	Fujiwara et al.	
2009/0271726	A1	10/2009	Gavimath et al.	715/771
2009/0284390	A1	11/2009	Lahner et al.	340/825.49
2009/0296601	A1	12/2009	Citrano, Iii et al.	370/254
2009/0326852	A1	12/2009	Vetter et al.	702/108
2010/0100766	A1	4/2010	Bengtsson et al.	714/23
2010/0114347	A1	5/2010	Dheenathayalan et al.	700/97
2010/0114549	A1	5/2010	Kolavi	703/13
2010/0145476	A1	6/2010	Junk et al.	700/7
2010/0150425	A1 *	6/2010	Kalteis	382/141
2010/0220630	A1	9/2010	Kalika et al.	370/254
2010/0290084	A1	11/2010	Russell, III et al.	358/1.15
2010/0290351	A1	11/2010	Toepke et al.	370/250
2010/0290359	A1	11/2010	Dewey et al.	370/252
2010/0293363	A1	11/2010	Meyer et al.	713/1
2011/0117529	A1	5/2011	Barash et al.	434/265
2011/0238188	A1	9/2011	Washiro	700/19
2012/0038458	A1	2/2012	Toepke et al.	340/6.1
2012/0038548	A1	2/2012	Toepke et al.	345/156
2012/0040316	A1	2/2012	Mathiowetz et al.	434/219
2012/0040698	A1	2/2012	Ferguson et al.	455/457
2012/0041744	A1	2/2012	Kantzes et al.	703/13
2012/0046911	A1	2/2012	Mathiowetz et al.	702/184

FOREIGN PATENT DOCUMENTS

DE	10245176	4/2004
DE	102007035158	1/2009
DE	102008029406	12/2009
DE	102009028195	2/2011
EP	1515208	3/2005
EP	1916582	4/2008
EP	2071427	6/2009
EP	2077473	7/2009
EP	2148259	1/2010
EP	2204705	7/2010
GB	2382418	5/2003
GB	2 394 124	4/2004
JP	9051583	2/1997
JP	H11233965	8/1999
JP	2001337004	7/2001
JP	2004505337	2/2004
JP	2004265131 A	9/2004
JP	2006285632 A1	10/2006
JP	2007-91381	4/2007
JP	2008165193	7/2008
JP	2009038544	2/2009
KR	20060078883	7/2006
WO	WO 01/35190	5/2001
WO	WO 02/086662	10/2002
WO	WO 2006/016845	2/2006
WO	WO 2008/042074	4/2008
WO	WO 2008/077358	7/2008
WO	WO 2008/096216	8/2008
WO	WO 2008/127632	10/2008
WO	WO 2009/003146	12/2008
WO	WO 2009/003148	12/2008
WO	WO2009026032	2/2009
WO	WO 2009/074544	6/2009

OTHER PUBLICATIONS

ABB Limited: "Wireless Instrumentation Jargon Buster". Information bulletin instrumentation ABB no IB/INST-018, Mar. 3, 2009,

(56) **References Cited**

OTHER PUBLICATIONS

XP002596601. Retrieved from the Internet: URL:http://www05.abb.com/global/scot/scot203.nsf/veritydisplay/be00ec76ef07e978c125756e003157b9/$File/IB_INST_018_1.pdf.
Notification of Transmittal of the International Search Report and the Written Opinion from the International Application No. PCT/US2010/021764.
David Gustafsson: "WirelessHART—Implementation and Evaluation on Wireless Sensors". Masters's Degree Project, KTH University, Electrical Engineering, Apr. 1, 2009, pp. 1-39, XP002596602, Stockholm, Sweden. Retrieved from the Internet: URL:http://www.ee.kth.se/php/modules/publications/reports/2009/XR-EE-RT%202009:003.pdf.
Notification of Transmittal of the International Search Report and the Written Opinion for the International application No. PCT/US2010/034848 dated Aug. 26, 2010.
Possio Bluetooth to WLAN Gateway PX20: Full Product Description retrieved from http://www.blueunplugged.com/p.aspx?p=105816.
1420 Wireless Gateway: Product Data Sheet 00813-0100-4420, Rev BA Mar. 2008. Emerson Process Management.
Smart Wireless Gateway (WirelessHART™). Quick Installation Guide 00825-0200-4420, Rev BA. Aug. 2009. Emerson Process Management.
Rosemount 3051S Wireless Series Scalable Pressure, Flow, and Level Solutions. Reference Manual 00809-0100-4802, rev BA. Aug. 2007. Emerson Process Management.
EPO Communication pursuant to Rules 161(I) and 162 EPC for European patent application No. 10701430.0 dated Aug. 30, 2011.
Invitation to Pay Additional Fees for international patent application No. PCT/US2010/034949 dated Sep. 17, 2010.
Technical Data Sheet: VIATOR® USB HART® Interface (Model 010031). MACTek Measurement and Control Technologies.
VIATOR® Bluetooth® Wireless Technology Interface for use with HART field devices. MACTek Measurement and Control Technologies retrieved from www.mactekcorp.com/product5.htm.
Product Data Sheet: VIATOR RS232. MACTek Measurement and Control Technologies retrieved from www.mactekcorp.com/product1.htm.
Notification of Transmittal of the International Search Report and the Written Opinion from the International Application No. PCT/US2010/034889.
Notification of Transmittal of the International Search Report and the Written Opinion from the International Application No. PCT/US2010/034949.
EPO Communication from related European application No. 10730279.6 dated Jan. 13, 2012.
EPO Communication from related European application No. 10730281.2 dated Jan. 13, 2012.
EPO Communication from related European application No. 10725543.2 dated Jan. 12, 2012.
Rosemount 3051 SMV Quick Installation Guide 00825-0100-4803 Rev BA. Apr. 2011.
Invitation to Pay Additional Fees from the International Application No. PCT/US2011/045673 dated Jan. 16, 2012.
Notification of Transmittal of the International Search Report and the Written Opinion from the International Application No. PCT/US2011/045680 dated Jul. 6, 2012.
Notification of Transmittal of the International Search Report and the Written Opinion from the International Application No. PCT/US2011/045681 dated Jan. 5, 2012.
475 Field Communicator. User's Guide XP007919976. Aug. 2009. www.fieldcommunicator.com by Emerson Process Management.
1420 Wireless Gateway. Reference Manual 00809-0100-4420, Rev BA. Aug. 2007. Emerson Process Management.
Invitation to pay additional fees from the related International patent application No. PCT/US2011/045679 dated Aug. 6, 2012.
Invitation to pay additional fees from the related International patent application No. PCT/US2011/045664 dated Aug. 9, 2012.
Invitation to pay additional fees from the related International patent application No. PCT/US2011/045676 dated Jul. 30, 2012.
Lee S W et al: "Honam Petrochemical Corporation Uses Simulator for Ethylene Plant Operator Training", Processing of the Industrial Computing Conference. Houston, Oct. 18-23, 1992. pp. 219-222.
Kurrle H-P et al.: "Trainingssimulator Zur Ausbildung Von Chemikanten und Anlagenfahrern. Otraining Simulator for the Training of Process Workers (Chemikanten) and Operators", Automatisierungstechnische Praxis—ATP, Oldenbourg Indusrieverlag, Munchen, DE, vol. 36, No. 7, Jul. 1, 1994. Abstract, Section 2.
Invitation to pay additional fees from the related International patent application No. PCT/US2011/045665 dated Aug. 23, 2012.
Bushman J B: "Ally: An Operator's Associate for Cooperative Supervisory Control Systems", IEEE Transactions on Systems, Man and Cybernetics, IEEE Inc. New York, US, vol. 23, No. 1, Jan. 1, 1993, pp. 111-128.
First Communication for the related European patent application No. 107302812 dated Oct. 11, 2012.
International Search Report and Written Opinion from the related International patent application No. PCT/US2011/045664 dated Nov. 6, 2012.
International Search Report and Written Opinion from the related International patent application No. PCT/US2011/045679 dated Nov. 6, 2012.
International Search Report and Written Opinion from the related International patent application No. PCT/US2011/045665 dated Nov. 6, 2012.
First Communication from related European patent application No. 107255432 dated Oct. 11, 2012.
First Communication from related European patent application No. 107302796 dated Oct. 19, 2012.
Office Action from related Russian application No. 2011151063 dated Nov. 12, 2012.
First Office Action from related Japanese application No. 2015511048, dated Jan. 29, 2013.
First Office Action from counterpart Japanese patent application No. 2013-521969, dispatched on Jan. 28, 2014. 5 pages.
First Office Action from counterpart Chinese patent application No. 201180001615.0, issued Aug. 29, 2013. 14 pages.
Second Office Action from counterpart Chinese patent application No. 201180001615.0, Issued Feb. 26, 2014. 17 pages.
Notification Regarding Results of Examination on Patentability from Russian Application No. 2013108906, dated Jun. 24, 2014 with English Translation. 10 pages.
Office Action from Canadian Patent Application No. 2,806,244 dated Jul. 22, 2014. 3 pages.
Decision of Rejection from Japanese Application No. 2013-521969, dispatch date Sep. 16, 2014, 6 pages with English Translation.
Notification of Reasons for Rejection from corresponding Japanese patent application No. 2013-521969, from Sep. 15, 2015. [49 pages with English translation].
Communication pursuant to Article 94(3) EPC fromcorresponding European patent application No. 11739256.3, from Sep. 10, 2015, [5 pages].

* cited by examiner

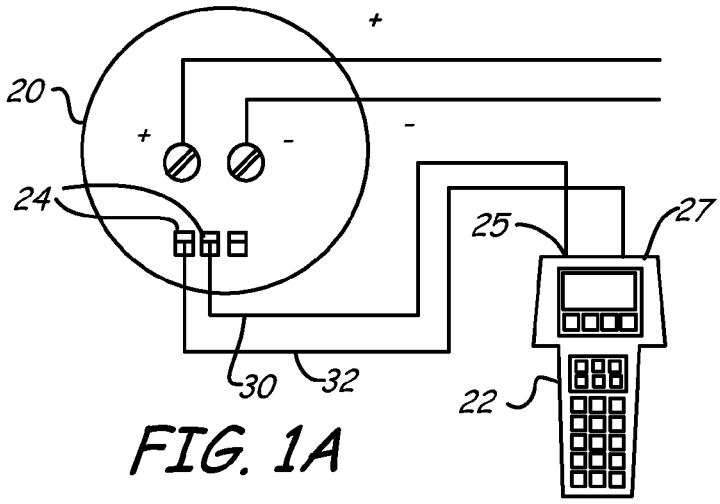


FIG. 1A

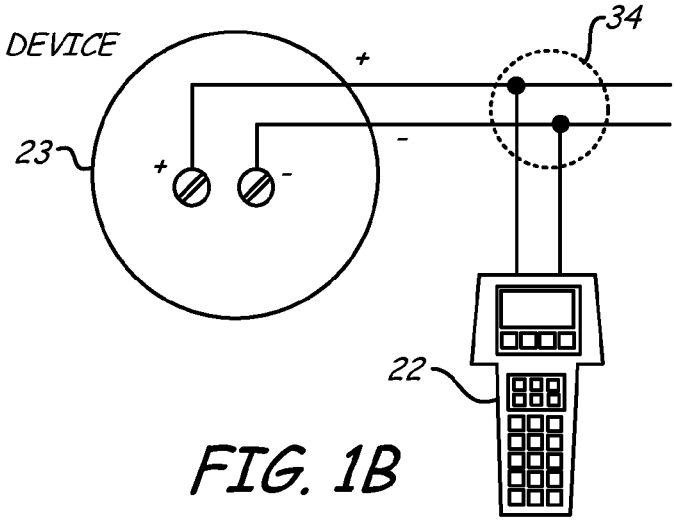


FIG. 1B

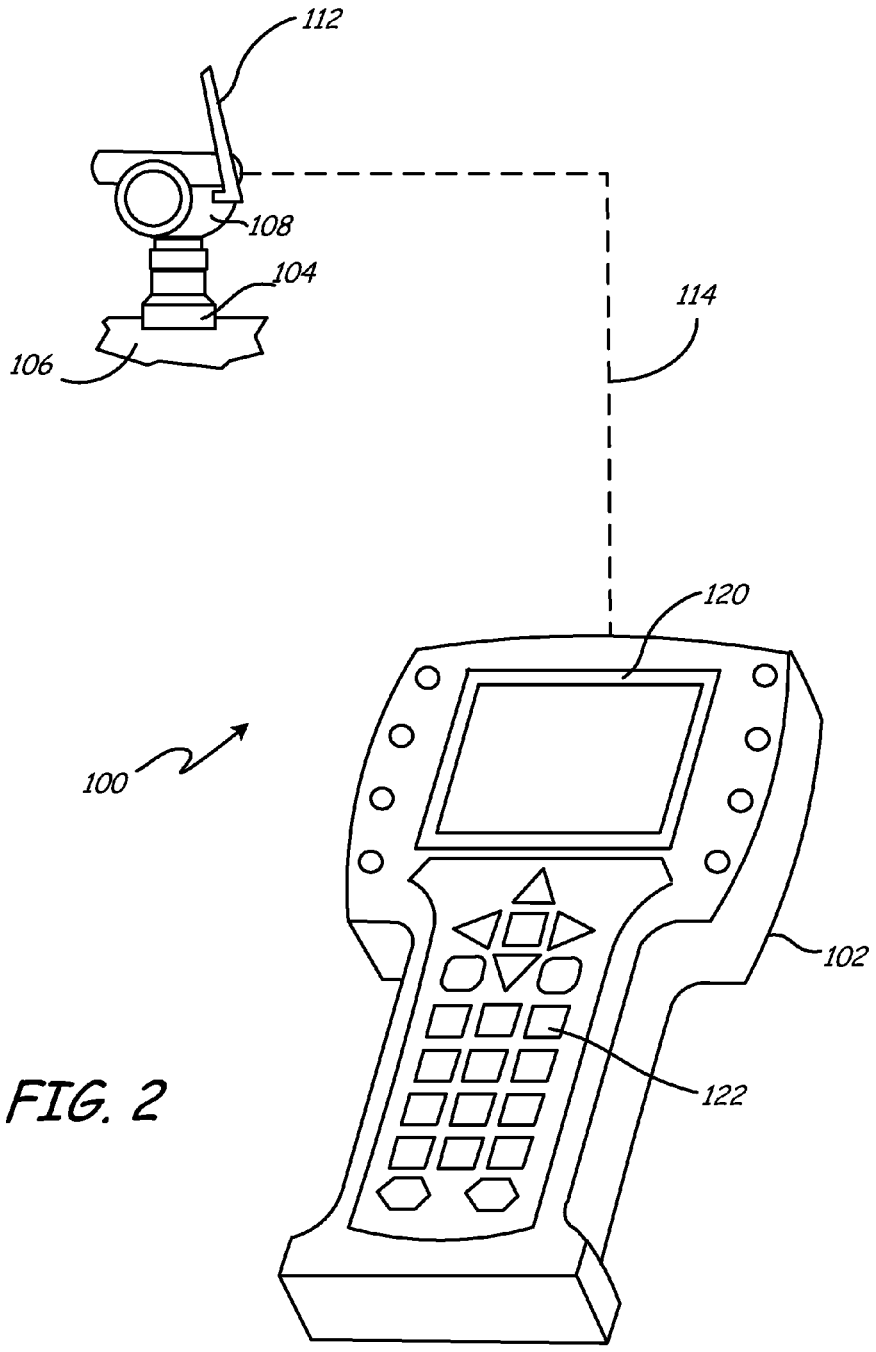


FIG. 2

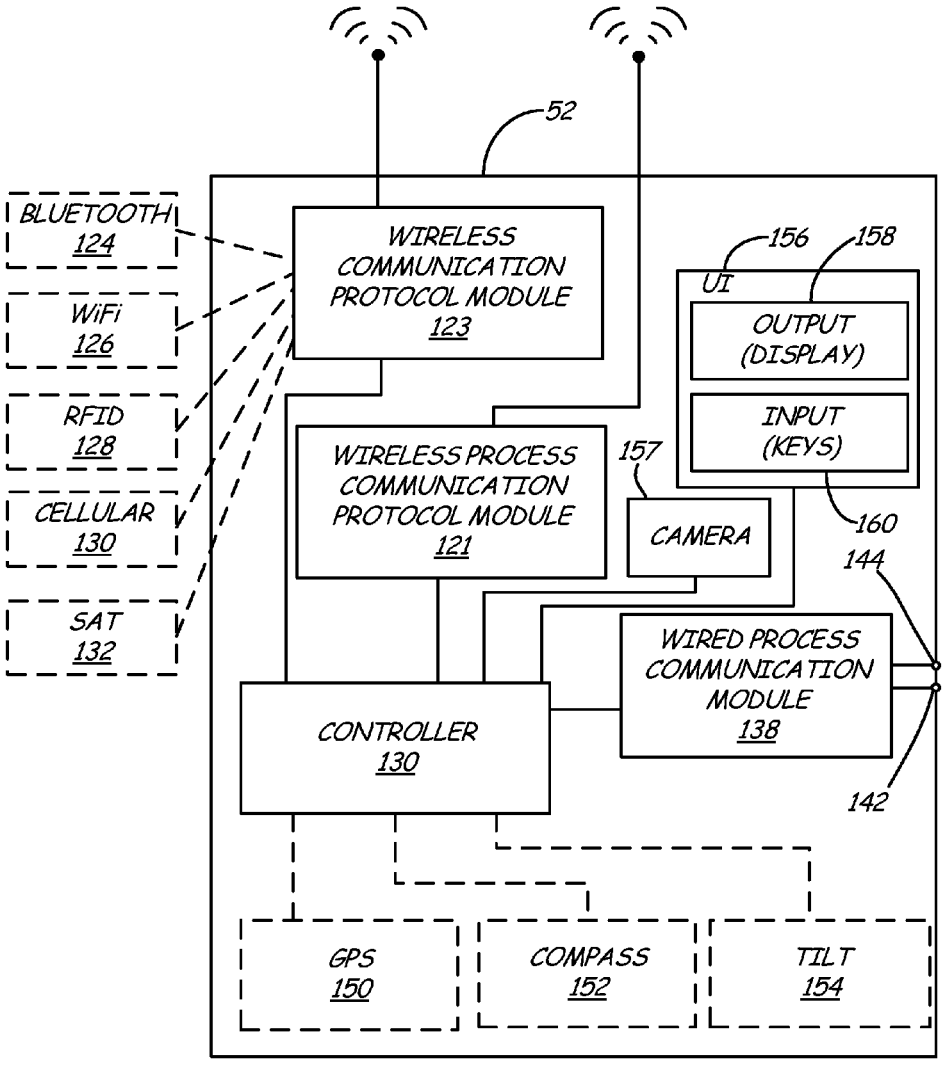

52
BLUETOOTH
124
WiFi
126
RFID
128
CELLULAR
130
SAT
132
WIRELESS COMMUNICATION PROTOCOL MODULE
123
WIRELESS PROCESS COMMUNICATION PROTOCOL MODULE
121
CONTROLLER
130
156
158
UI
OUTPUT (DISPLAY)
INPUT (KEYS)
157
CAMERA
160
144
WIRED PROCESS COMMUNICATION MODULE
138
142
GPS
150
COMPASS
152
TILT
154

FIG. 3

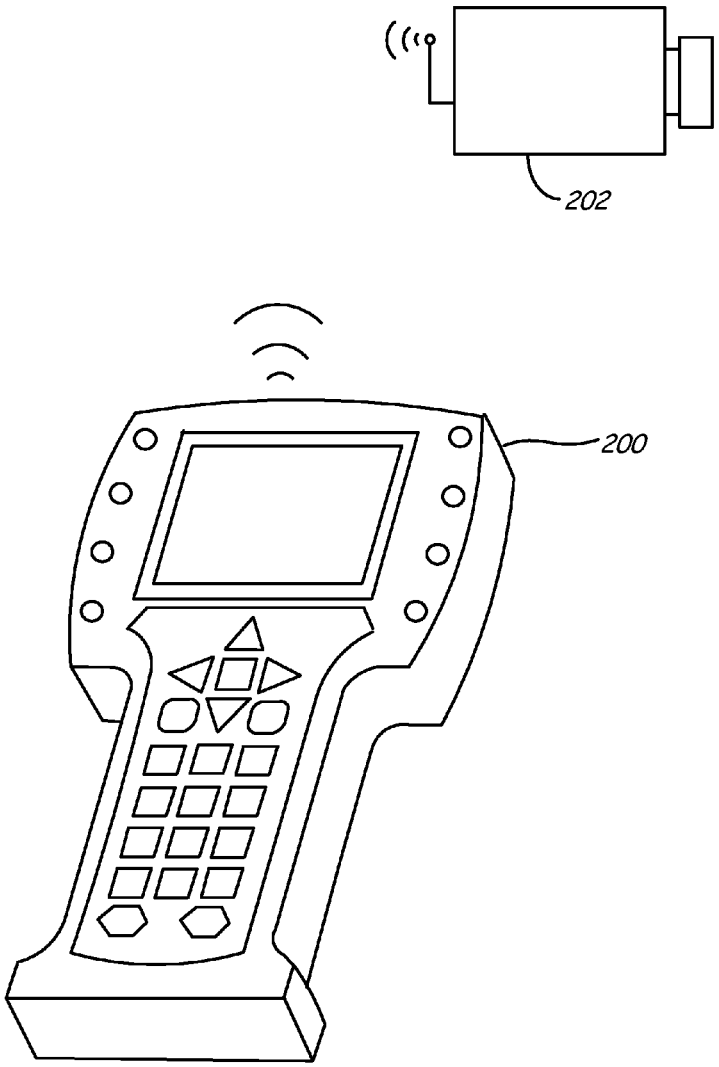


FIG. 4

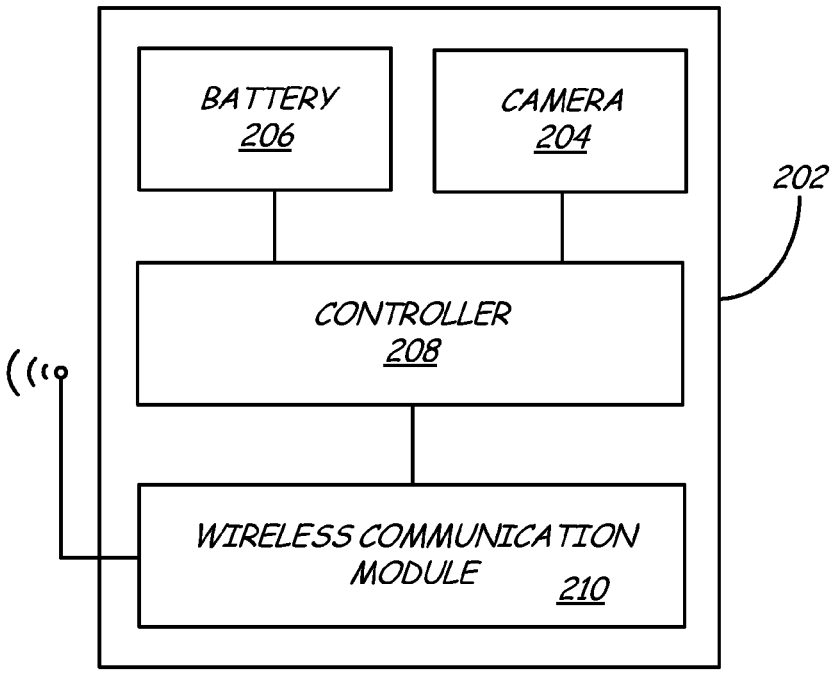

BATTERY
206
CAMERA
204
202
CONTROLLER
208
WIRELESS COMMUNICATION
MODULE
210

FIG. 5

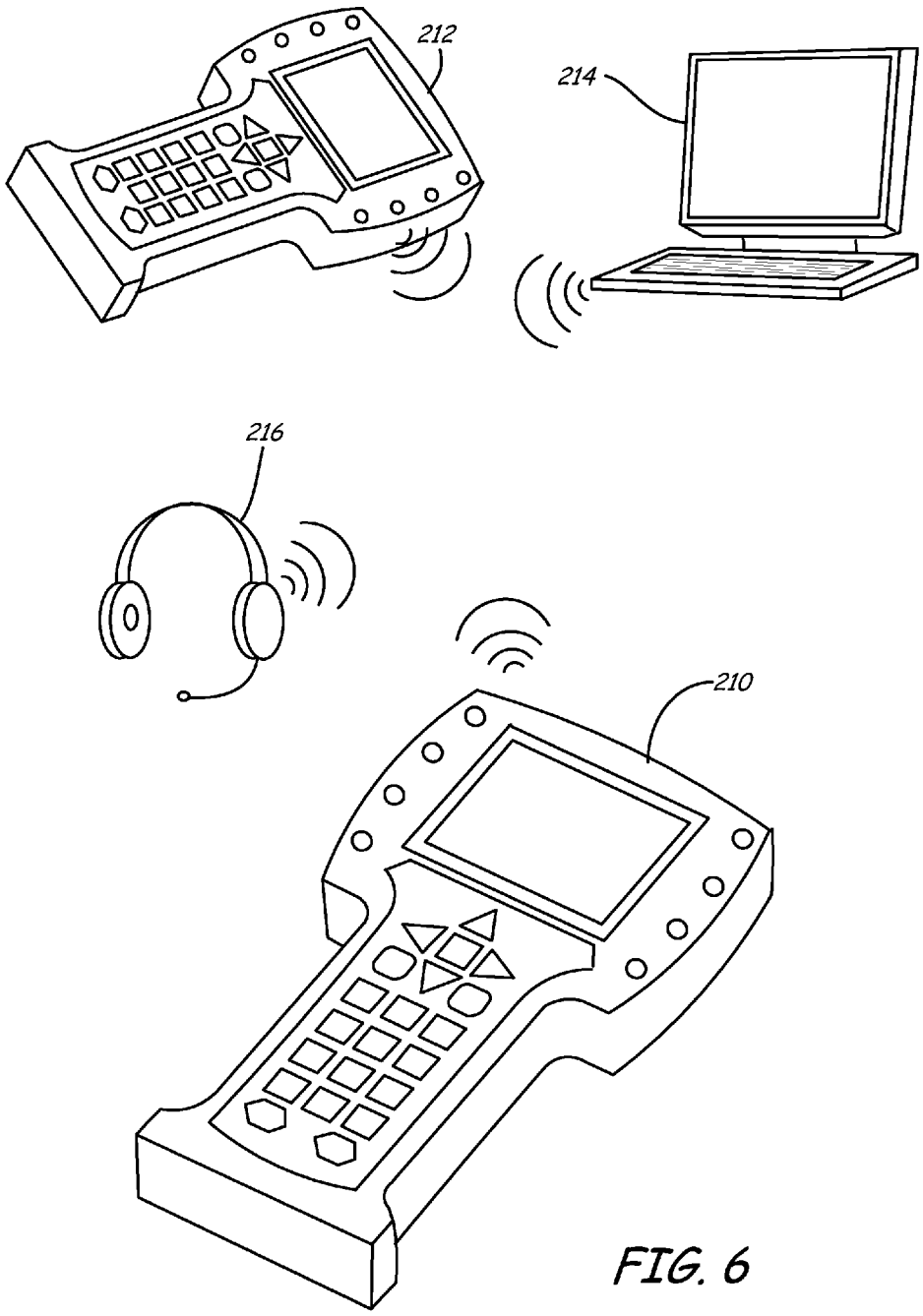


FIG. 6

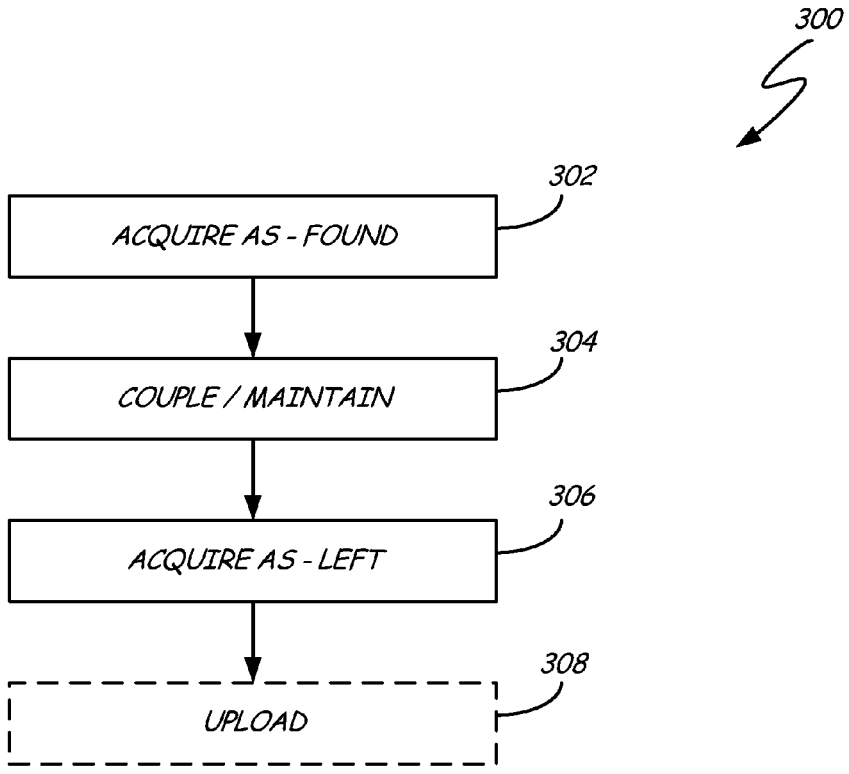

300
302
ACQUIRE AS - FOUND
304
COUPLE / MAINTAIN
306
ACQUIRE AS - LEFT
308
UPLOAD

FIG. 7

INTRINSICALLY-SAFE HANDHELD FIELD MAINTENANCE TOOL WITH IMAGE AND/OR SOUND CAPTURE

CROSS-REFERENCE TO RELATED APPLICATION

The present application is based on and claims the benefit of U.S. provisional patent application Ser. No. 61/368,477, filed Jul. 28, 2010, the content of which is hereby incorporated by reference in its entirety.

BACKGROUND

Handheld field maintenance tools are known. Such tools are highly useful in the process control and measurement industry to allow operators to conveniently communicate with and/or interrogate field devices in a given process installation. Examples of such process installations include petroleum, pharmaceutical, chemical, pulp, and other fluid processing installations. In such installations, the process control and measurement network may include tens or even hundreds of various field devices which periodically require maintenance to ensure that such devices are functioning properly and/or calibrated. Moreover, when one or more errors in the process control and measurement installation are detected, the use of a handheld field maintenance tool allows a technician to quickly diagnose such errors in the field. Handheld field maintenance tools are generally used to configure, calibrate, and diagnose problems relative to intelligent field devices using digital process communication protocols.

Since at least some process installations may involve highly volatile, or even explosive, environments, it is often beneficial, or even required, for field devices and the handheld field maintenance tools used with such field devices to comply with intrinsic safety requirements. These requirements help ensure that compliant electrical devices will not generate a source of ignition even under fault conditions. One example of Intrinsic Safety requirements is set forth in: APPROVAL STANDARD INTRINSICALLY SAFE APPARATUS AND ASSOCIATED APPARATUS FOR USE IN CLASS I, II and III, DIVISION NUMBER 1 HAZARDOUS (CLASSIFIED) LOCATIONS, CLASS NUMBER 3610, promulgated by Factory Mutual Research October, 1998. An example of a handheld field maintenance tool that complies with intrinsic safety requirements includes that sold under trade designation Model 475 Field Communicator, available from Emerson Process Management of Austin, Tex.

SUMMARY

An intrinsically-safe handheld field maintenance tool includes a process communication module configured communicatively couple to a field device. A camera is configured to obtain at least one image relative to the field device. A controller is coupled to the process communication module and operably coupled to the camera. The controller is configured to store the at least one image relative to the field device. The handheld field maintenance tool may also include or employ an audio input device to capture audio files.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1**A and **1**B are diagrammatic views of a handheld field maintenance tool with which embodiments of the invention are particularly useful.

FIG. **2** is a diagrammatic view of a handheld field maintenance tool with which embodiments of the present invention are particularly useful.

FIG. **3** is a block diagram of a handheld field maintenance tool in accordance with an embodiment of the present invention.

FIG. **4** is a diagrammatic view of an intrinsically safe handheld field maintenance tool interacting with an intrinsically safe camera/input device in accordance with an embodiment of the present invention.

FIG. **5** is a block diagram of an external input module in accordance with an embodiment of the present invention.

FIG. **6** is a diagrammatic view of handheld field maintenance tool receiving and/or sending previously-created audio/photo/video information from/to another handheld field maintenance tool or a personal computer in accordance with an embodiment of the present invention.

FIG. **7** is a flow diagram of a method of performing field maintenance using a handheld field maintenance tool in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION

FIGS. **1**A and **1**B are diagrammatic views of a handheld field maintenance tool **22** coupled to field devices **20**, **23**. As shown in FIG. **1**A, handheld field maintenance tool **22** includes a pair of terminals **25**, **27** that couple to test leads **30**, **32**, respectively, which are then coupled to terminals **24** of field device **20**. Terminals **24** may be dedicated terminals to allow such a handheld field maintenance tool to couple to device **20** and interact with device **20**. The utilization of terminals **25**, **27** to couple to field device illustrates an example of a wired connection between handheld field maintenance tool **22** and field device **20**.

FIG. **1**B shows an alternate arrangement where handheld field maintenance tool **22** couples directly to the process control loop **34** to which field device **23** is coupled. In either case, the wired connection between the handheld field maintenance tool and the field device allows the handheld field maintenance tool to interact with the desired field device **20**, **23**.

FIG. **2** is a diagrammatic view of handheld field maintenance tool **102** interacting with wireless field device **104**. System **100** includes handheld field maintenance tool **102** communicating with field device **104**. Handheld field maintenance tool **102** is communicatively coupled to field device **104** via communication link **114**. Communication link **114** can take any suitable form including wired connections as shown in FIGS. **1**A and **1**B, as well as wireless communication techniques that are currently being used or being developed. Handheld field maintenance tool **102** allows a technician to interact with field device **104** to configure, calibrate, and/or diagnose problems with respect to field device **104** using a digital process communication protocol such as FOUNDATION™ Fieldbus and/or the HART® protocol. Handheld field maintenance tools, such as tool **102** can be used to save configuration data from field devices, such as field device **104**.

Field device **104** may be any device that senses a variable in the process and transmits information related to the variable over a process communication loop; such as a pressure or temperature. Field device **104** may also be a device that receives information from a process communication loop and sets a physical parameter, such as a valve closure, based on the information. Field device **104** is depicted as an industrial process fluid pressure transmitter having a pressure manifold **106** coupled thereto, and an electronics enclosure **108**. Field

device **104** is provided for illustrative purposes only. In reality, field device **104** may be any industrial device, such as a process fluid temperature transmitter, process fluid level transmitter, process fluid flow transmitter, valve controller, or any other device that is useful in the measurement and/or control of industrial processes.

Handheld field maintenance tool **102** generally includes a user interface that comprises a display **120** as well as a number of user input buttons **122**. Display **120** may be any suitable display such as an active-matrix liquid crystal display, or any other suitable display that is able to provide useful information. Buttons **122** may comprise any suitable arrangement of buttons relative to any number of functions to which the handheld field maintenance tool may be directed. Buttons **122** may comprise a numeric keypad, an alphanumeric keypad, any suitable number of custom functions and/or navigation buttons, or any combination thereof.

FIG. **3** is a diagrammatic system block diagram of a handheld field maintenance tool in accordance with an embodiment of the present invention. It is preferred that tool **52** comply with at least one intrinsic safety specification, such as that listed above, in order to help ensure safety in potentially explosive environments. Handheld field maintenance tool **52** preferably includes at least one wireless process communication module **121**. Suitable examples for wireless process communication module **121** include a module that generates and/or receives proper signals in accordance with a known wireless communication protocol, such as the WirelessHART protocol (IEC 62591). Another wireless process communication protocol is set forth in ISA100.11a. While FIG. **3** shows a single wireless process communication module **121**, it is expressly contemplated that any suitable number of wireless process communication modules can be used to communicate in accordance with various wireless process communication protocols now in existence or later developed.

Handheld field maintenance tool **52** also includes at least one secondary wireless communication protocol module **123**. Wireless communication protocol module **123** can communicate in accordance with one or more of the options shown in phantom in FIG. **3**. Specifically, wireless communication protocol module **123** may communicate in accordance with a Bluetooth specification **124** (such as Bluetooth Specification 2.1 rated at Power Class 2; a Wi-Fi specification **126** (such as IEEE 802.11.a/b/g/n); a known RFID specification **128**; cellular communication techniques **130** (such as GSM/CDMA); and/or satellite communication **132**. These communication techniques and methodologies allow handheld field maintenance tool **52** to communicate directly with a wireless gateway or other suitable device either via direct wireless communication, or using the Internet. While one wireless communication protocol module **123** is shown in FIG. **3**, any suitable number may be used. Each of the wireless process communication protocol module **121** and wireless communication protocol module **123** is coupled to controller **130** which is also coupled to the wired process communication module **138**. Controller **130** is preferably a microprocessor that executes a sequence of instructions stored therein, or in memory coupled to controller **130**, to perform handheld field maintenance tasks. Wired process communication module **138** allows handheld field maintenance tool **52** to be physically coupled via a wired connection at terminals **142**, **144** to a field device. Examples of suitable wired process communication include the highway addressable remote transducer (HART®) protocol, the FOUNDATION™ Fieldbus protocol, Profibus and others.

Handheld field maintenance tool **52** includes a user interface module **156** for generating a user interface using display **120** and keys **122**. Module **156** can include suitable display driver circuitry **158** and/or memory to interact with display **120**. Module **156** also includes input circuitry **160** which is configured to interact with buttons **122** to receive user input. Additionally, in embodiments where display **120** includes a touchscreen, module **160** can include circuitry to generate user input data to controller **130** based upon a user's touch and/or gestures received by the touchscreen.

Handheld field maintenance tool includes or is coupled to camera **157**. Preferably camera **157** is an internal component of handheld field maintenance tool **52**. However, embodiments of the present invention do include camera **157** being a separate intrinsically-safe external module, such as that described below with respect to FIGS. **4** and **5**. Preferably, camera **157** is a known CCD (Charge Coupled Device) or CMOS Image Acquisition System. While it is preferred that camera **157** capture images (either still, video, or both) in the visible spectrum, some embodiments may include a camera that is sensitive to, or images, infrared radiation. Moreover, while embodiments of the present invention will generally be described with respect to a single camera, it is expressly contemplated that multiple such cameras could be used. For example, a first camera may be an internal component of handheld field maintenance tool **52** and be sensitive to the visible spectrum. A second camera **157** could be an intrinsically-safe external camera that transmits its image data to the handheld field maintenance tool using wireless communication. Further still, yet another external camera **157** could be configured to capture a video using high-speed image acquisition using a high frame rate (for example 1000 frames per second) to capture fleeting occurrences within a process installation.

Handheld field maintenance tool **52** can include a number of additional items that facilitate additional functionality. Specifically, tool **52** can include a position detection module, such as GPS module **150**. GPS module **150** can be configured to additionally use the Wide Area Augmentation System (WAAS) for improved accuracy and/or can be configured to operate using differential GPS techniques as appropriate. Module **150** is coupled to controller **130** to provide controller **130** with an indication of the geographic position of tool **52**. While position detection module **150** is preferably an internal component of tool **52**, it may be external and communicatively coupled thereto using a suitable wireless or wired communication protocol, such as Bluetooth **124**, RFID **128**, et cetera. Further, while position detection module **150** is generally described as GPS module **150**, other techniques for triangulating the position of the handheld field maintenance tool based upon relative strength of wireless communication with wireless transceivers having known fixed positions can be employed. Examples of such wireless triangulation techniques include triangulation of the position of handheld field maintenance tool **52** based upon communication with three or more fixed-position WiFi communication points, or access points. Further still, as set forth above, embodiments of the present invention may include the ability to employ one or more wireless process communication protocol modules, such as module **121**.

Additionally, tool **52** also preferably comprises compass module **152** coupled to controller **130** such that tool **52** can indicate the direction in which it is pointing. Finally, tool **52** can also include tilt module **154** coupled to controller **130** to provide an indication to controller **130** relative to an angle of inclination of tool **52** relative to gravity. However, additional axes of sensing are also contemplated.

The positional location module **150**, compass module **152** and tilt module **154** are particularly useful where a handheld

field maintenance tool helps a technician or engineer find the physical location of a wireless field device in the field. An oil refinery is often a very large process installation with many field devices positioned at various locations, some of which may not be readily visible. Position detection module **150** preferably provides position information to controller **130** such that images and/or video acquired by the handheld field maintenance tool is stored with meta data indicative of the geographic position of the handheld field maintenance tool when the image or video was acquired. Moreover, the compass heading is also preferably stored in the image or video metadata.

When a technician is out in the field, it may sometimes be useful for the technician to have the ability to either view a picture of a field device in its location (for the purposes of identification or to compare historical pictures to a current view) or to compare the noise generated by the device (a motor, for example) to that previously recorded. In accordance with an embodiment of the present invention, an intrinsically safe handheld field maintenance tool includes, or is operably coupled to, a video and/or audio input device that provides the ability to record audio and/or photo/video of a field device. Moreover, the handheld field maintenance tool is configured, through hardware, software, or a combination thereof, to associate the recorded audio and/or video of a field device with other device information, such as a device tag, geographic position, et cetera.

FIG. **4** is a diagrammatic view of an intrinsically safe handheld field maintenance tool **200** interacting, wirelessly, with an intrinsically safe camera/input device **202**. Preferably, handheld field maintenance tool **200** and external input device **202** communicate in accordance with one of the wireless communication technologies set forth with respect to FIG. **3**. More preferably, the communication is in accordance with either Bluetooth communication, or WiFi communication. Wireless communication is preferred over wired communication since wireless communication does not have wired connection ports, and thus facilitates compliance with intrinsic safety requirements. Input device **202** may be a photographic camera that is able to capture one or more still images in the field. Alternatively, or additionally, device **202** may be a video camera capable of capturing and storing/streaming, or otherwise communicating video and corresponding audio information. Device **202** may also be a high-speed camera to capture fleeting process events. Further still, embodiments where the camera or the input device **202** is external to handheld field maintenance tool **200** are particularly useful in situations where a technician cannot easily view a given area. In such circumstances, the input device can simply be placed in a convenient location for viewing, and the image or video information can be viewed on the technician's handheld field maintenance tool. Moreover, embodiments of the present invention also contemplate a single handheld field maintenance tool simultaneously communicating with a plurality of such external input devices **202**. In this manner, a technician viewing display **120** is able to simultaneously monitor conditions at a plurality of locations in the field. While the embodiment described above with respect to FIG. **4** employs wireless communication between the camera/input device **202** and the handheld field maintenance tool, embodiments of the present invention can be practiced where camera/input device **202** is physically coupled to the handheld field maintenance tool. In such instances, communication therebetween would preferably be via wired communication, such as through a Universal Serial Bus (USB) connection.

FIG. **5** is a block diagram of external input module **202** in accordance with an embodiment of the present invention. Module **202** includes camera subsystem **204** which may be a known CCD (Charge Coupled Device) or CMOS image acquisition system. Preferably, input device **202** is powered by an internal battery **206** that may be rechargeable. Input device **202** preferably includes a controller **208**, which is preferably a microprocessor. Controller **208** includes, or is coupled to, suitable memory to contain a number of program instructions to execute the functions of image acquisition, video or photo streaming, image or photo transfer, or other suitable functions. Additionally, the memory preferably includes sufficient capacity to store a substantial number of individual images, and/or videos. Input device **202** also includes a wireless communication module **210** which preferably operates in accordance with either a Bluetooth specification or a WiFi specification. Both such specifications support high-speed data transfer over a relatively limited physical proximity, such as tens of meters.

FIG. **6** is a diagrammatic view of handheld field maintenance tool **200** receiving and/or sending previously-created audio/photo/video information from/to another handheld field maintenance tool **212**, or a personal computer **214**, in accordance with an embodiment of the present invention. Handheld field maintenance tool **200** is also preferably capable of loading previously created audio/photo/video information from either another handheld field maintenance tool, or a personal computer. The previously-created audio/photo/video information could have been previously created by another handheld field maintenance tool, such as tool **214**, created using another type or recording device, such as a digital camera, and stored on personal computer **214**, et cetera. Handheld field maintenance tool **200** allows the technician to import this audio/video/photo information and associate such information with a field device's tag/unique identification such that the next time the handheld field maintenance tool **200** connects to the field device, the technician will be able to call up, or otherwise invoke the audio/photo/video information and view it on the display of the handheld field maintenance tool and/or listen to it on headset **216** communicating with the handheld field maintenance tool via Bluetooth. Moreover, the technician also has the ability to create new information and add it to the handheld, or otherwise associate it with the field device. Such new audio/photo/video information can also be uploaded to PC **214**, handheld field maintenance tool **200** and/or maintained in a library for that field device. The audio/photo/video information could also be associated with one or more assets in an asset management system.

FIG. **7** is a flow diagram of a method of performing field maintenance using a handheld field maintenance tool in accordance with an embodiment of the present invention. Method **300** begins at block **302** where a technician employs a handheld field maintenance tool to acquire an image and/or video of a field device prior to working on the field device. This is an "as-found" image of the field device. There may be more than one as-found image. For example, multiple images or video from different views may be acquired. Additionally, multiple types of camera may be used for the as-found images. For example, a still camera may take an as-found high-resolution photo in the visible spectrum, and an as-found video may be acquired in the infrared spectrum.

Next, at block **304**, the technician couples the handheld field maintenance tool to the field device and performs the require maintenance work, such as calibration, diagnosis, repair, et cetera. At block **306**, the technician uses the handheld field maintenance tool to acquire the "as-left" image of

the field device after the maintenance has been completed at block **304**. Both the as-found and as-left images or videos are stored in the handheld field maintenance tool. Preferably, optional step **308** is executed where the as-found and as-left images or videos are uploaded to another device or system, such as an asset management system. In this way, field maintenance may be better documented. The archival of such images over time may also be useful for identifying wear or corrosion, or other conditions that occur slowly over time.

Although the present invention has been described with reference to particular embodiments, workers skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the invention.

What is claimed is:

1. A handheld field maintenance tool comprising:

a process communication module configured to communicatively couple to a field device and obtain a unique identification tag from the field device;

a camera configured to obtain a first image and a second image relative to the field device;

a wireless communication protocol module configured to communicatively couple to a wireless gateway;

a global positioning system (GPS) module configured to determine a geographic location of the handheld field maintenance tool when the first image and the second image are obtained;

a controller coupled to the process communication module and the wireless communication module, and operably coupled to the camera and the GPS module, the controller being configured to:

acquire the first image from the camera,

link the unique identification tag to the first image,

store the first image in memory as an as-found image based on the unique identification tag,

perform maintenance on the field device,

acquire the second image from the camera,

link the unique identification tag to the second image,

store the second image in memory as an as-left image based on the unique identification tag,

store the geographic location as metadata in the memory based on the unique identification tag,

access a library using the wireless gateway,

store the first image and the second image in the library based on the unique identification tag, and

store the metadata in the library based on the unique identification tag.

2. The handheld field maintenance tool of claim **1**, wherein the camera is an internal component of the handheld field maintenance tool.

3. The handheld field maintenance tool of claim **1**, wherein the first image includes a first photograph of the entire field device and the second image includes a second photograph of the entire field device.

4. The handheld field maintenance tool of claim **1**, wherein the camera is an external module, and wherein the handheld field maintenance tool and the camera communicate using short-range, high speed wireless communication.

5. The handheld field maintenance tool of claim **1**, and further comprising:

a compass module configured to determine a pointing direction of the handheld maintenance tool; and

wherein the controller is operably coupled to the compass module and further configured to include the pointing direction with the metadata.

6. The handheld field maintenance tool of claim **1**, and further comprising:

a tilt module configured to determine an angle of inclination of the handheld maintenance tool; and

wherein the controller is operably coupled to the tilt module and further configured to include the angle of inclination with the metadata.

7. A method of field maintenance using an intrinsically-safe handheld field maintenance tool, the method comprising:

acquiring at least one as-found image relative to a field device;

coupling the handheld field maintenance tool to the field device and performing at least one maintenance function on the field device;

receiving a unique identification of the field device from the field device;

acquiring at least one as-left image relative to the field device after completion of the at least one maintenance function;

determining a geographic location of the handheld field maintenance tool when the at least one maintenance function is performed;

determining a pointing direction of the handheld maintenance tool when the at least one maintenance function is performed;

determining an angle of inclination of the handheld maintenance tool when the at least one maintenance function is performed;

storing the at least one as-found image and the at least one as-left image based on the unique identification;

storing the geographic location, the pointing direction, and the angle of inclination as metadata relating to the field device; and

wherein the intrinsically-safe handheld field maintenance tool complies with at least one intrinsic safety specification such that it will not generate a source of ignition even under fault conditions.

* * * * *